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## **PATENT APPLICATION**

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## **ANTI-MUD PACKING SEAL GLAND**

### **Cross-Reference to Related Application**

This application claims priority to provisional application S.N. 60/392,814, filed July 1, 2002.

### **Field of the Invention**

This invention relates in general to earth-boring roller cone drill bits, and in particular to features for reducing mud packing around the seal gland.

### **Background of the Invention**

Rolling cone earth boring bits have been used for many years for drilling wells. The bit has a body with at least one leg, usually three. A bearing pin depends from each bit leg, extending inward and downward toward the axis of rotation of the bit body. A cone with teeth on its exterior mounts rotatably to each bearing pin.

The cone has a cavity that fits over the bearing pin. The cavity has an entrance portion or mouth adjacent the junction of the bit leg and the bearing pin. A seal is located at the entrance to seal the cavity from cuttings and drilling mud. Most well drilling rolling cone bits are filled with a lubricant that is sealed by the seal at the cavity mouth.

Many different seals have been used in the past as well as today. One type has a rigid seal ring that extends around the bearing pin and is urged by an elastomeric energizer ring into sliding engagement with a seal face in the cone cavity. The seal face rotates with the cone, while the seal ring and energizer ring are stationary with the bearing pin. An elastomeric excluder ring may be located between the bit leg and the outer ends of the energizer ring for keeping drilling mud and cuttings from the seal. While successful, sometimes mud packing occurs at the seal, causing damages to the seal.

## **Summary of the Invention**

In this invention, the annular seal cavity that contains the seal is made non-uniform. The volume of the seal cavity differs when measured around the outer diameter of the bearing pin, with at least one point having a greater volume or lesser volume than other points in the seal cavity. Consequently, as the cone rotates, the volume changes cyclically, creating a pumping action to circulate drilling fluid from the seal cavity.

In one embodiment, the difference in volume is accomplished by changing the radial width of the seal cavity from one point to another. This is preferably done by making the mouth eccentric relative to the bearing pin axis. The mouth is preferably circular, but has its axis offset from the bearing pin axis.

In one embodiment, the eccentric groove of the mouth is spaced radially from the seal assembly. In another embodiment, the eccentric groove of the mouth is located outward from the seal and is closely spaced to a seal boss formed on the bearing pin.

In a third embodiment, the backface of the cone contains a plurality of vanes. The vanes rotate in close proximity to a last machined surface formed on the bearing pin to provide a positive pressure.

### **Brief Description of the Drawings**

Figure 1 is a partial sectional view of one roller cone and bearing pin of a bit constructed in accordance with this invention.

Figure 2 is an enlarged view of a portion of the bit of Figure 1.

Figure 3 is a sectional view of the bit of Figure 1, taken along the line 3-3 of Figure 2, with the seal assembly omitted.

Figure 4 is a sectional view similar to Figure 3, but showing the cone further rotated from the position of Figure 3.

Figure 5 is a partial sectional view of an alternate embodiment of a bit constructed in accordance with this invention.

Figure 6 is a partial sectional view of another alternate embodiment of a bit constructed in accordance with this invention.

Figure 7 is an end view of the cone of the bit of Figure 6, the cone shown removed and with the teeth omitted.

### **Detailed Description of the Invention**

Referring to Figure 1, bit 11 has three legs 13, only one of which is shown. Each bit leg 13 has a depending bearing pin 15, which is a cylindrical member that points downward and inward relative to an axis of rotation of bit 11. A cone 17 is rotatably carried on bearing pin 15. Cone 17 has a cone body 19 and a plurality of teeth 21. Teeth 21 are shown to be steel teeth that are milled from body 19, but they could also be hard metal inserts, such as tungsten carbide, inserted into holes within cone body 19. Cone body 19 has a bearing cavity 23 that fits over bearing pin 15. In this embodiment, a seal insert ring 25 is press-fitted within cavity 23 and rotates with cone 17.

Cone 17 has a backface 27 that is located on the outer end of cone 17 and faces bit leg 13. Backface 27 is placed very close to but not touching a last machined surface 29 formed at the base of bearing pin 15 where it joins bit leg 13. Last machined surface 29 also includes a depending portion on the lower side of bit leg 13, called a shirttail. A seal assembly 31 is located at the base of bearing pin 15 for sealing lubricant within cone cavity 23.

Referring to Figure 2, seal assembly 31 in this embodiment includes a metal ring 33 that is stationary with bearing pin 15 and engages seal insert 25 in rotating sliding contact. An elastomeric energizing ring 35 is stationarily located in an annular recess 36 on bearing pin 15 and provides a bias force to urge metal ring 33 against the seal face of insert 25. An elastomeric excluder ring 37 is deformed between last machined surface 29 and the outer ends of metal ring 33 and energizing ring 35 for preventing entry of drilling mud and debris. Numerous other seal assemblies are suitable in lieu of seal assembly 31.

Cone 17 is retained on bearing pin 15 by a plurality of locking balls 41, shown in Figure 1, although other types of retention are possible, such as snap rings. Lubricant passages 43 supply lubricant from a reservoir (not shown) to locking balls 41 and to the bearing spaces in sliding contact between cone 17 and bearing pin 15.

Cone cavity 23 has an entrance portion or mouth 40 that is an annular surface located radially outward from seal assembly 31 relative to an axis 47 of bearing pin 15. An annular seal cavity 39, which contains seal assembly 31, is defined by annular recess 36 on the outer diameter of bearing pin 15 and cone mouth 40. Seal cavity 39 has a radial width, measured between recess 36 and mouth 40. Seal cavity 39 also has an axial depth, measured from last machined surface 29 to the outer end of seal insert ring 25. The volume of seal cavity 39, measured at any point around recess 36 is the radial width times the axial depth. This volume is not constant around recess 36, rather varies continuously.

In the preferred embodiment, the varying volume is due to a varying radial width of seal cavity 39. As shown in Figures 2 - 4, mouth 40 is eccentric relative to bearing pin axis 47. In the preferred embodiment, mouth 40 is circular, but has an axis 48 that is offset from bearing pin axis 47. The eccentricity results in varying radial width for seal cavity 39. The width varies from a minimum radial width W1, located on the upper side in Figures 2 and 3 to a maximum radial width W2, located on the lower side in Figures 2 and 3. The minimum radial width point W1 is 180 degrees from the maximum radial width point W2. The change in width is gradual from minimum width point W1 to maximum width point W2.

Mouth 40 is spaced radially outward of the outer diameter of metal seal ring 33, defining an annular clearance between the outer diameter of metal seal ring 33 and mouth 40. The

annular clearance forms a part of seal cavity 39. Because of the eccentricity, this annular clearance also varies in width also.

The dotted lines 49 of Figures 3 and 4 indicate mouth 40 if it were conventional, which is circular and concentric to bearing pin axis 47. Mouth 40 is preferably made eccentric by increasing the diameter slightly and shifting its axis 48 relative to the axis of rotation 47. As cone 17 rotates, minimum width portion W1 and maximum width portion W2 rotate past any selected point on seal assembly 31 once per revolution.

In operation, when bit 11 is rotated, cone 17 will rotate concentrically about bearing pin axis 47 as indicated by the arrows of Figures 3 and 4. Figure 4 shows cone body 19 rotated approximately 90° from the position of Figure 3. The minimum and maximum width points W1 and W2 of cone mouth 40 thus have rotated 90° from the position shown in Figure 3. As cone 17 rotates, seal cavity 39 changes in width, and thus volume, at each point on the circumference of metal seal ring 33. The wider width point W2 will rotate with cone 17 about bearing pin 15 as well as the lesser width point W1.

Figure 5 shows a bit 51 that is similar to bit 11, however, it does not use a metal face seal 33 (Fig. 2). Bit 51 has a bit leg 53 and bearing pin 55. Cone 57 has an annular recess or seal gland 59 at the entrance to its cavity that receives an elastomeric seal 61, preferably an O-ring. Seal 61 is deformed between seal gland 59 and the outer diameter of bearing pin 55 close to bit leg 53. Seal gland 59 extends to a mouth of the cavity of cone 57 at backface 65.

An eccentric grooved portion 63 is formed at the mouth of the cone cavity, which is at the corner between seal gland 59 and backface 65. Eccentric portion 63 is preferably a circular groove that has an axis offset from the axis of rotation of cone 57. A seal boss 64 is machined on bit leg 57 radially inward from eccentric portion 63. The radial gap between the cylindrical wall

of eccentric portion 63 and seal boss 64 varies around the circumference of seal boss 64. This change in radial width results in minimum and maximum radial width portions rotating around seal boss 64 as cone 57 rotates. The change in radial width between eccentric portion 63 and seal boss 64 results in a cyclic change in volume in seal gland 64. This creates a pumping action tending to pump drilling mud from seal gland 59 outward to reduce mud packing. Eccentric portion 63 thus functions in the same manner as the eccentric mouth 40 of the first embodiment to reduce mud packing.

Figure 6 shows another embodiment. Bit 69 has a bit leg 71, from which depends a bearing pin 73. A cone 75 rotates concentrically on bearing pin 73. Cone 75 has a seal gland 77 that contains a seal 79. Seal 79 is shown as an elastomeric O-ring, but it could be other types. Cone 75 has a backface 81 surrounding mouth 82 of the cavity of cone 75. As in the other embodiments, backface 81 is closely spaced to but not touching last machined surface 83. Last machined surface 83 is contained in a plane perpendicular to the axis of bearing pin 73. The lower portion of last machined surface 83 is referred to as a shirttail.

In this embodiment, a plurality of curved vanes 85 are formed on backface 81 as shown in Figure 7. Vanes 85 extend from cavity mouth 82 to the outer diameter of backface 81 and are spaced from last machined surface 83 by a gap. Each vane 85 curves in a manner to create a differential pressure between the seal cavity surrounding gland 77 and the exterior, with the pressure being greater in the seal cavity 77. This pressure tends to cause drilling fluid to circulate out of seal gland 77. Vanes 85 cause the volume of the seal cavity, which includes seal gland 77 and the gap between backface 85 and last machined surface 83, to change at any selected point on last machined surface 83 due to rotation of cone 75.

Other configurations to provide a variable volume for the seal cavity are feasible. For example, the cone mouth could be noncircular but rotate about the bearing pin axis. The cone mouth could be oblong or have one or more recess portions within it that result in a noncircular inner diameter at the entrance portion of the cone cavity. These recess portions could be formed at different radial distances from the seal assembly. The change in seal cavity volume need not occur gradually as in the first embodiment. There could be more than one maximum width and minimum width portions, as provided by the vanes of the third embodiment. Rather than gaps between the cone and bearing pin differing in radial dimension, recess portions could extend axially from the backface of the cutter at different distances to change the volume of the seal cavity at different points around the circumference of the cavity mouth. In that instance, the mouth could have a circular diameter that is concentric with the bearing pin axis.

The invention has significant advantages. This rotational change in volume of seal cavity 39 causes agitation of the drilling mud that locates around seal assembly 31 (Figure 1). The agitation discourages mud packing in this area. The dynamic pressure within the seal gland changes as the cone rotates, causing a positive pressure in the seal gland over the exterior to circulate drilling fluid from the seal gland. This agitation is accomplished without any addition components.

While the invention has been shown in only three of its forms, it should be apparent to those skilled in the art that it is not so limited but is susceptible to various modifications without departing from the scope of the invention.